REMARKS/ARGUMENTS

Claims 1-18 are pending in the Application.

The undersigned gratefully acknowledges the opportunity to discuss this application with the Examiner during a recent telephone conversation. These remarks and arguments are being set forth in view thereof and after having reviewed and considered the Final Office Action in detail.

In Paragraph 2 which begins on page 2 of the Office Action, claims 1 and 5 are rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent 5,968,264 of Iida in view of U.S. Patent 6,277,501 of Fujikawa. In Paragraph 3 on page 3 of the Office Action, claims 2, 6 and 9-18 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Iida '264 in view of Fujikawa '501 and further in view of U.S. Patent 6,162,708 of Tamatsuka. In Paragraph 4 on page 4 of the Office Action, claims 3 and 7 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Iida '264 in view of Fujikawa '501 and further in view of U.S. Patent 5,954,873 of Hourai. In Paragraph 5 on page 5 of the Office Action, claims 4 and 8 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Iida '264 in view of Fujikawa '501 and Tamatsuka '708 and further in view of Hourai '873. In Paragraph 6 on page 5 of the Office Action, claims 1, 3, 5, 7 and 9 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Hourai '873 in view of Fujikawa '501. In Paragraph 7 on page 7 of the Office Action, claims 2, 4, 6, 8 and 10-18 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Hourai '873 in view of Fujikawa '501 and further in view of Tamatsuka '708. These rejections, which are essentially the same as those made in the prior Office Action, are again respectfully traversed for the same reasons set forth in Applicants' prior Amendment of February 25, 2003.

By way of brief summary, and as set forth in Applicants' Amendment of February 25, 2003, the present invention cannot be derived from the attempted combination of Iida and Fujikawa because, on the one hand, Iida does not describe or suggest doping with carbon or promoting precipitation of oxygen, while on the other hand, Fujikawa does not describe or suggest growing a silicon single crystal with an N-region. Any attempt at arriving at the present invention based on the combination of such references could result only with the benefit of hindsight and the teaching of the present invention. The pulling of a silicon crystal with an N-region while doping with carbon, in the case of the present invention, is based on the discovery that by doping with carbon, the single crystal having the N-region can be pulled faster than a single crystal in the case of not doping with carbon, and that improvement of productivity of the silicon single crystal having no grow-in defect and decrease in cost can be achieved. Without the knowledge that a pulling rate possible to obtain the N-region shifts faster with doping of carbon, doping of the N-region crystal with carbon in a manner of the present invention cannot be derived.

As Applicants have also previously pointed out, as long as it is unknown that the pulling rate possible to obtain the N-region shifts faster by doping with carbon, one of ordinary skill in the art could not derive the present invention from the attempted combination of references. Tamatsuka discloses a silicon wafer doping with nitrogen to improve a getting capacity. Iida does not describe or suggest doping with nitrogen and carbon or promoting precipitation of oxygen, while Fujikawa, on the other hand, does not describe or suggest doping with nitrogen and growing a silicon single crystal with an N-region. Furthermore, Tamatsuka does not describe or suggest growing a silicon single crystal with an N-region and doping with carbon.

In accordance with the invention, by doping with nitrogen, the range of the pulling rate possible to obtain an N-region is expanded. Further in accordance with the invention, a silicon single crystal is doped with not only nitrogen but also carbon to solve the problem that if nitrogen concentration is to be doped is increased, expansion of the OSF region or generation of secondary defects may occur, so the very high nitrogen concentration cannot be employed, and nitrogen can stabilize the oxygen precipitation nuclei at high temperatures. However, the formation of precipitation nuclei at low temperatures is not a concern.

By doping with both carbon and nitrogen dopant in accordance with the invention, both productivity and yield of the entire N-region wafer are simultaneously improved. Additionally, stable oxygen precipitation nuclei in a high temperature can be increased under the effect of nitrogen and stable oxygen precipitation nuclei in a low temperature can also be increased under the effect of carbon. The acceleration effect of oxygen precipitation is very strong in various temperature ranges, so that even if any heat treatment is performed in a device process, high IG ability can be shown.

None of the cited references show or describe compensation of the weak point of doping nitrogen by doping with carbon to obtain a synergistic effect. In Tamatsuka, for example, because the acceleration effect of oxygen precipitation is obtained by doping with nitrogen, it is not necessary for one of ordinary skill in the art to dope further with carbon, in view of the teaching of such reference. To dope with not only nitrogen but with carbon, in the manner of the present invention, it must be acknowledged that by doping with carbon, the single crystal having the N-region can be pulled faster, and the acceleration effect of oxygen precipitation is obtained at a low temperature. To the contrary, by doping with nitrogen, the single crystal having the N-region cannot be pulled faster, very high nitrogen concentration cannot be employed because generation of a secondary defect may

occur, and nitrogen is not concerned with the formation of precipitation nuclei at low temperatures. These considerations are not acknowledged in the cited art.

Regarding the combination of Hourai and Fujikawa, it was previously pointed out that Hourai discloses a method of forming a silicon wafer with an N-region, in the manner of the present invention, with careful control of the pulling rate and temperature gradient, but such reference does not disclose that the silicon single crystal is pulled while doping with carbon. However, neither Hourai nor Fujikawa discloses or suggests that by doping the N-region crystal with carbon, the pulling rate possible to obtain the N-region shifts faster. A person of ordinary skill in the art would not be led to the present invention from such a combination.

Addressing the Examiner's response to arguments, which begins on page 8 of the Final Office Action, the Examiner asserts therein that one cannot show nonobviousness by attacking references individually where the rejections are based on combinations of references. As further stated therein, the features upon which the Applicants rely of promoting precipitation of oxygen are not recited in the claims. With respect to obviousness based on improper hindsight reasoning, it is stated that as long as it takes into account only knowledge which was within the level of ordinary skill at the time the claimed invention was made, and does not include knowledge gleaned only from the Applicants' disclosures, such a reconstruction is proper. The motivation to combine the reference is said to be taken directly from the prior art. With respect to Applicants' argument that the single crystal having the N-region can be pulled faster than a single crystal in the case of not doping with carbon, it is said that Applicants' recognition of another advantage which would flow naturally from following the suggestion of the prior art cannot be the basis for patentability when the differences would otherwise be obvious.

These arguments are respectfully traversed as explained hereafter.

Independent claims 1 and 9 of the present Application combine carbon doping with the N-region crystal. The idea of such combination is based upon the finding of the present inventors that "by doping with carbon, the single crystal having the N-region can be pulled faster than a single crystal in the case of not doping with carbon, and improvement of productivity of the silicon single crystal having no grown-in defect and decrease in cost can be achieved" (as described at page 8, lines 16-21, and page 15, lines 2-17, of the specification).

Therefore, as long as it is unknown that a pulling rate possible to obtain the N-region shifts faster by doping with carbon, the idea of doping the N-region crystal with carbon, in the manner of the present invention, cannot be derived.

On the contrary, the Office Action attempts to derive the present invention from the combination of Fujikawa and Iida. Iida discloses a method of forming a silicon wafer with an N-region formed over the entire surface. Fujikawa teaches growing a silicon single crystal while controlling the oxygen concentration and the carbon concentration.

Therefore, the question is whether one of ordinary skill in the art could derive the present invention from the combination of Fujikawa and Iida. Iida does not disclose or suggest not only doping with carbon but also promoting precipitation of oxygen. On the other hand, Fujikawa does not describe or suggest growing a crystal having the N-region. Consequently, the suggestion to combine the references is not made in either of them. Moreover, the object of Iida, as described at column 2, line 2 from the bottom to column 3, line 6, is to obtain a silicon single crystal such that a defect density is very low over the entire crystal cross section, and the oxygen concentration distribution is improved over the surface of a silicon wafer. The object of Fujikawa, as described in column 5, line 2 from the bottom to column 6, line 15, is to provide a method which simplifies processing as much as possible, and which obtains sufficient gettering capabilities. Such objects are completely different

from each other, and there is no motivation for one of ordinary skill in the art to combine the two references. Inherently, neither reference describes even the problem to be solved by the present invention that "in order to produce the N-region wafer, its pulling rate is necessarily lowered about 0.5 mm/min, and it results in low productivity and high cost" as described on page 6, lines 18-25 of the specification. Accordingly, it is impossible to combine such references to solve such a problem.

As previously described, the combination of Iida and Fujikawa is apparently based on only the teaching of the present invention, in other words hindsight, so that it is improper.

At lines 5 and 6 of page 9 of the Office Action, it is asserted that "the fact that applicant has recognized another advantage which would flow naturally from following the suggestion of the prior art cannot be the basis for patentability". In this connection, and as further evidence of the hindsight employed in combining references so as to reject the claims of the present invention, the prior art has no suggestion that a crystal having the N-region is doped with carbon. Applicants respectfully question where and how such suggestion is made in the reference. Applicants have carefully reviewed the reference and cannot find any such suggestion. Namely, the finding that the single crystal having the N-region doped with carbon can be pulled faster is not another advantage which would flow naturally from following the suggestion of the prior art. Rather, the finding is found for the first time by the inventors of the present invention. In other words, the finding is described only in the present specification and is not at all suggested by the prior art. Again, the attempted combination of Iida and Fujikawa is based solely upon the teaching described by the present invention that a crystal having the N-region is doped with carbon.

Moreover, the present invention has the distinctive and unexpected effect that by growing the silicon single crystal having the N-region while doping with

carbon, the silicon single crystal having no grown-in defect can be pulled faster and improvement of productivity of the silicon single crystal having no grown-in defect and decrease in cost can be achieved, which cannot be carried out conventionally (see lines 16-21 of page 8 of the specification). Therefore, it is clear that the present invention is not obvious over Iida and Fujikawa.

Again, independent claims 1 and 9 involve the combination of carbon doping with a crystal having the N-region. Claims 2-7 and 10 depend, directly or indirectly from such claims, and contain all of the limitations thereof. Therefore, such claims are submitted to clearly distinguish patentably over the prior art.

Similar reasoning can be applied with respect to the assertion at page 9, line 9 of the Office Action that one cannot show nonobviousness by attacking references individually. Again, it is clear that the present invention is not obvious over the attempted combinations of references.

Regarding independent claims 11, 13, 15 and 17, the common essential requirements of such claims are the combining of concentrations of carbon, nitrogen, and oxygen at each specific narrow concentration range. In other words, a CZ silicon single crystal has a carbon concentration, nitrogen concentration and oxygen concentration of 0.1 to 1 ppma, 1×10^{13} to 1×10^{14} number/cm^3 and 15 to 25 ppma, respectively, or 1 to 3 ppma, 1×10^{14} to 5×10^{15} number/cm^3 and 10 to 15 ppma, respectively. When such a combination of specific narrow concentration ranges is employed, the generation of secondary defects can be prevented.

Nevertheless, the cited references do not at all describe or suggest that specific concentration ranges of each impurity are combined, and according to this, the generation of secondary defects can be prevented.

Pages 2 and 3 of the Office Action refer to concentration. More specifically, it is asserted that Fujikawa describes a carbon concentration of $0.3\text{-}2.5 \times 10^{16}$

atoms/cm^3 (0.06-0.5 ppma), and that Tamatsuka describes a nitrogen concentration of 1 x 10^{10}-5 x 10^{15}/cm^3, and an oxygen concentration of 18 ppma or less.

As described above, although individual concentration of these concentrations partially overlaps with each concentration in the case of the present invention, the cited references do not disclose or suggest that the specific narrow concentration ranges defined by the present invention are selected from such concentrations of the cited references, and each concentration is combined at selected concentrations.

Thus, the present invention as defined in the claims is not obvious over the cited references.

In conclusion, claims 1-18 are submitted to clearly distinguish patentably over the attempted combinations of prior art references for the reasons discussed above. Therefore, reconsideration and allowance are respectfully requested.

In view of the foregoing, it is respectfully submitted that the application is in condition for allowance. Reexamination and reconsideration of the application, as amended, are requested.

If for any reason the Examiner finds the application other than in condition for allowance, the Examiner is requested to call the undersigned attorney at the Los Angeles, California telephone number (213) 337-6846 to discuss the steps necessary for placing the application in condition for allowance.

If there are any fees due in connection with the filing of this response, please charge the fees to our Deposit Account No. 50-1314.

Respectfully submitted,
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